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MARTINE & PENILLA, LLP
710 LAKEWAY DRIVE
SUITE 170
SUNNYVALE, CA 94085

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EXAMINER
RUGGLES, JOHN S

ART UNIT	PAPER NUMBER
1756	

DATE MAILED: 08/29/2003

Please find below and/or attached an Office communication concerning this application or proceeding.

Office Action Summary	Application No.	Applicant(s)	
	09/894,230	KO ET AL.	
	Examiner	Art Unit	
	John Ruggles	1756	

-- Th MAILING DATE of this communication app ars on th cov r sh t with th correspondenc addr ss --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If the period for reply specified above is less than thirty (30) days, a reply within the statutory minimum of thirty (30) days will be considered timely.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133).
- Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on *06 June 2003* .

2a)☒ This action is **FINAL**. 2b)☐ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☒ Claim(s) *1-36* is/are pending in the application.

4a) Of the above claim(s) *1-15 and 25-36* is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☒ Claim(s) *16-24* is/are rejected.

7)☐ Claim(s) _____ is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

9)☒ The specification is objected to by the Examiner.

10)☒ The drawing(s) filed on *06 June 2003* is/are: a)☒ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

11)☐ The proposed drawing correction filed on _____ is: a)☐ approved b)☐ disapproved by the Examiner.

If approved, corrected drawings are required in reply to this Office action.

12)☐ The oath or declaration is objected to by the Examiner.

Priority under 35 U.S.C. §§ 119 and 120

13)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☐ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____ .

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

14)☐ Acknowledgment is made of a claim for domestic priority under 35 U.S.C. § 119(e) (to a provisional application).

a) ☐ The translation of the foreign language provisional application has been received.

15)☐ Acknowledgment is made of a claim for domestic priority under 35 U.S.C. §§ 120 and/or 121.

Attachment(s)

1) ☐ Notice of References Cited (PTO-892)
2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3) ☐ Information Disclosure Statement(s) (PTO-1449) Paper No(s) _____ .
4) ☐ Interview Summary (PTO-413) Paper No(s). _____ .
5) ☐ Notice of Informal Patent Application (PTO-152)
6) ☐ Other: .

DETAILED ACTION

Election/Restrictions

Applicant's confirmation in Paper No. 5, filed 06 June 2003, of the previous telephone election without traverse of Group II, claims 16-24 in response to the Office action of Paper No. 4 is acknowledged. Accordingly, claims 1-15 and 25-36 remain withdrawn from further consideration by the examiner, 37 CFR 1.142(b), as being drawn to non-elected inventions.

Information Disclosure Statement

The information disclosure statement filed 13 August 2002 still fails to comply with 37 CFR 1.98(a)(1), which requires a list of all patents, publications, or other information submitted for consideration by the Office, as was previously stated in the last Office action of Paper No. 4, mailed on 03 March 2003.

The listing of references in the specification is not a proper information disclosure statement. 37 CFR 1.98(b) requires a list of all patents, publications, or other information submitted for consideration by the Office, and MPEP § 609 A (1) states, "the list may not be incorporated into the specification but must be submitted in a separate paper." Therefore, unless the references have been cited by the examiner on form PTO-892, they have not been considered.

Drawings

The newly corrected drawings labeled as Figures 1-5 were received on 06 June 2003 in response to the previous objections of Paper No. 4. These newly corrected drawings are

accepted and render the previous objections moot. Accordingly, these previous objections are now withdrawn.

Specification

The majority of the previous objections to the disclosure of Paper No. 4, including the requested change to the brief description of Figure 2 found on page 7, have been addressed by the newly filed amendments to the specification of Paper No. 5.

However, the disclosure is still objected to because of the following informalities: on page 7, in the brief descriptions of Figure 3, Figure 4, and Figure 5, "illustrates" should still be changed to --illustrates a-- in each occurrence, as previously stated in the objections of Paper No. 4.

Appropriate correction is required.

Claim Rejections - 35 USC § 112

The previous rejection of claim 23 under the first paragraph of 35 U.S.C. 112 in Paper No. 4 has been overcome by the currently amended version of claim 23 filed in Paper No. 5, which finds support in the 4th through 6th lines of the first full paragraph describing Figure 3 on instant page 11 of the original specification. Accordingly, this previous rejection is now withdrawn.

The previous rejection of claims 17 and 24 under the second paragraph of 35 U.S.C. 112 in Paper No. 4 have been overcome by the currently amended versions of claims 17 and 24 filed in Paper No. 5. Accordingly, this previous rejection is also now withdrawn.

Claim Rejections - 35 USC § 102

The previous rejection of claims 16-17 under 35 U.S.C. 102(e) in Paper No. 4 as being anticipated by Sato (US Patent 6,337,163) is now withdrawn in view of currently amended claims 16-17 filed in Paper No. 5.

Claim Rejections - 35 USC § 103

The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

Claims 16-17 are rejected under 35 U.S.C. 103(a) as being unpatentable over Sato (US Patent 6,337,163).

Sato teaches a process for improving etching resistance (increasing selectivity) of an organosilicon photoresist by first energy beam imaging of the photoresist with or without post-exposure baking, developing, then second energy beam post-treatment (exposing) of the imaged photoresist (column 97, lines 42-54). Column 5, lines 6-7 show alternative use of a charged beam (electron or ion beam specified at column 3, lines 59-61) as the first energy beam and

ultraviolet (UV) rays as the second energy beam. The second energy beam (UV) exposure cross-links organosilicon polymer in the imaged photoresist to form a hardened etching mask having improved resistance to subsequent etching (column 82, lines 15-18 and column 96, lines 56-64). Specific examples of organosilicon compounds useful in the photoresist are polysilane and polysilene shown by formulas [1-1] to [1-114] in columns 6-28, but particular attention is drawn to those showing Si-H and $Si-CH_3$ bonds, such as those in formulas [1-14] to [1-16] found in column 8 (instant claim 17 interpreted only as disclosed in the last line of instant page 11). The organosilicon photoresist containing an organosilicon compound can be selectively hardened with a charged beam by conversion into a silicon oxide/carbide-like film in order to improve etching resistance for use as an etching mask. Alternatively, the organosilicon photoresist may be used as an underlying layer that also functions as an antireflective film during exposure of an overlying top resist (column 4, lines 4-21, column 5, lines 25-67, and column 96, line 64 to column 97, line 4). The organosilicon photoresist can also contain a cross-linking agent for curing/hardening the organosilicon compound to provide increased solvent and heat resistance, as well as improving etching resistance for use as an etching mask (column 28, line 65 to column 29, line 1 and column 96, lines 56-63). Examples of cross-linking agents having multiple (double or triple) bonds are shown by formulas [3-1] to [3-88] in columns 61-72 and are described as reacting at Si-H bonds to cross-link the organosilicon polymer under the effect of heat or light at column 61, line 50 to column 62, line 51. Other examples of cross-linking agents are described at column 82, line 1 to column 96, line 55. The overlying top resist is not particularly limited (e.g., the top resist does not have to contain an organosilicon compound (non-organosilicon resist), the top resist can be selected according to the particular end use as

either a positive or a negative resist, etc., column 97, lines 5-29). Example 1 shows coating of a SiO_2 work film 11 on a silicon wafer 10, adding an underlying film having an organosilicon compound 12, and overcoating the underlying film with a resist 13 as shown in Figure 1A. The resist is baked, exposed by KrF excimer laser, baked again, then developed to form a line-and-space pattern 14 as shown in Figure 1B. An accelerating voltage of 1.8 kV was used to project an electron beam 15 on the resist pattern 14 for detecting the position of the resist pattern. A separate electron beam at a much stronger accelerating voltage of 10 kV was then used to expose and harden at least upper regions 16 at portions of the organosilicon underlying film 12 as shown in Figure 1C. Then, the resist pattern 14 and electron beam regions 16 of the underlying film are used as etching masks for dry etching of the unexposed/unhardened regions of the underlying film to form an underlying film pattern portion 17 using the resist pattern 14 as an etching mask and another underlying film pattern portion 18 using the hardened regions 16 as an etching mask as shown in Figure 1D. Both of these etching masks provided excellent anisotropic etching of the unhardened/unexposed regions of the underlying film. The unhardened organosilicon underlying film was more selectively etched than either the overlying resist pattern 14 or the electron beam hardened regions 16 of the organosilicon underlying film. The previous electron beam exposure of at least the top regions 16 of the organosilicon underlying film resulted in conversion of the organosilicon compound to oxide/carbide silicon-like film regions, which are much harder to etch than the unexposed regions of the organosilicon underlying film. It is also noted that while comparison of Figures 1C and 1D suggests a reduction in thickness of the patterned upper resist 14 during etching, no such reduction in thickness is apparent for the electron beam hardened organosilicon regions 16. This suggests that the hardened organosilicon

regions present greater resistance to subsequent etching than does the non-organosilicon resist 14 (column 99, line 25 to column 102, line 30). Example 5 shows an alternative embodiment in which the underlayer is a non-organosilicon antireflective layer 72 between the work film 71 to be etched and an overlying resist film 73, as shown in Figure 5A. In this case, electron beam exposure 75 of the overlying resist film comes first, followed by baking, developing, and helium neon laser detecting of the first resist pattern. KrF excimer laser exposure 80 of additional regions of the remaining overlying resist comes next, then further baking and developing to form patterns 76 and 81 as shown in Figures 5B-5E (column 170, line 17 to column 108, line 8). This latter example lays out a potential use for a non-organosilicon underlayer in a similar process that involves similar patterning of an overlying resist (which could be an organosilicon photoresist) before etching of an underlying layer.

Sato does not specifically require that the organosilicon photoresist be formed and patterned over the non-organosilicon resist before selective etching of an underlying layer.

However, it would have been obvious to one of ordinary skill in the art at the time the invention was made to have reversed the order of the non-organosilicon resist and the organosilicon photoresist so that the underlying layer was the non-organosilicon resist and the top layer was the organosilicon photoresist as taught and suggested by Sato. This is because both layers are resists patterned by charged beam or UV imaging and the overall etching resistance as an etching mask for improved selectivity is a combination of the etching resistance of both layers when added together, regardless of order. Furthermore, the hardened organosilicon photoresist (having at least a top surface converted to an oxide/carbide film) did not appear to be weakened by subsequent etching and is expected to provide greater etching

resistance than the non-organosilicon resist, which was weakened by a reduction in thickness caused by exposure to the etchant during subsequent etching. Therefore, the organosilicon photoresist, as the stronger etching mask, should logically be the first line of defense as the top resist layer over an underlying non-organosilicon resist, as the weaker etching mask, in protecting the non-etched areas of the underlying substrate or work film from overetching.

Claim 18 is rejected under 35 U.S.C. 103(a) as being unpatentable over Sato in view of Tsai, et al. (US Patent 5,899,748).

While showing UV exposure of a developed organosilicon photoresist image to cross-link and harden the photoresist layer followed by subsequent etching through the hardened photoresist layer, Sato does not specify that the UV exposure should be conducted in an etching chamber.

Tsai specifies UV exposure of a photoresist layer in an etching chamber that provides UV emission and implies the advantage of simplified processing over UV exposure and etching in separate chambers (which would require taking the photoresist layer off-line for UV treatment before returning the photoresist layer to the etching chamber described at column 6, lines 30-39).

It would have been obvious to one of ordinary skill in the art at the time the invention was made to expose the photoresist to UV hardening as taught by Sato in an etching chamber that provides UV emission prior to etching with the expectation of simplifying processing (by avoiding taking the photoresist to a separate UV chamber before returning the photoresist to the etching chamber) as taught by Tsai.

Claims 19-23 are rejected under 35 U.S.C. 103(a) as being unpatentable over Sato in view of Tsai, further in view of Kishimura (US Patent 5,123,998), further in view of Singh, et al. (US Patent 6,479,820), and further in view of George, et al. (US Patent 4,980,563).

Sato and Tsai do not specify use of argon (Ar) inert gas flowing to the etching chamber at about 1000 to 3000 sccm during UV exposure generated by neon (Ne) gas and do not specify that the flow rate of Ne must be about 0.2% to 0.8% of the flow rate of Ar. Also, Sato and Tsai do not require striking plasma composed of Ar and Ne gases to generate UV in the etching chamber.

Kishimura teaches UV imaging (exposing) of a photoresist in inert gas (e.g., Ne, Ar, He, N_2, etc., column 10, lines 5-9) for more efficient cross-linking of the photoresist by the UV exposure (column 5, lines 58-68), selective silylation to incorporate silicon (Si) into the photoresist by forming Si-CH_3 bonds (shown in Figure 2B) with the unexposed areas of the photoresist (column 6, lines 21-25), followed by developing and dry etching by O_2 reactive ion etching (RIE) to convert the silylated regions of the photoresist to SiO_2 as a powerful shielding material to O_2 plasma, allowing only the exposed regions to be removed by etching (column 6, lines 26-31).

Singh describes plasma post-treatment of a developed photoresist image in which the plasma includes one or more inert gases (e.g., Ar, Ne, He, etc.) flowing at 10 sccm to 10 slm (10,000 sccm) under a pressure of 0.0001 to 1,000 Torr to ionize and maintain the inert gas in a plasma state at column 6, lines 7-23.

George shows a UV lithography process and apparatus using a UV source gas (e.g., Ne for 85 nm, He for 65 nm, Ar for 130 nm, krypton (Kr) for 150 nm, xenon (Xe) for 170 nm, etc.) at column 3, lines 22-32.

It would have been obvious to one of ordinary skill in the art at the time the invention was made to combine the UV hardening exposure of a developed photoresist in an etching chamber that provides UV emission and etching using the hardened photoresist in the same chamber as taught by Sato and Tsai with Ar inert gas flow to the etching chamber during UV hardening at a flow rate of 10 to 10,000 sccm as taught by Singh (encompassing the Ar inert gas flow rate of about 1,000 to 3,000 sccm in instant claims 19-20) for more efficient cross-linking of the photoresist by the UV exposure as shown by Kishimura. It would also have been obvious to control inert gas pressure in the etching chamber during plasma post-treatment (UV exposure) of the developed photoresist image at 0.0001 to 1,000 Torr as shown by Singh to strike and maintain the inert gas plasma in the etching chamber as described by Singh.

It would have been obvious to one of ordinary skill in the art at the time the invention was made to combine the UV exposure hardening of developed photoresist and etching taught by Sato and Tsai with a UV generation source having (1) Ne gas (instant claim 21) to obtain an 85 nm emission or (2) a mixture of Ne and Ar (such as that obtained by a flow rate of Ne between about 0.2% and 0.8% of the flow rate of Ar, instant claim 22) to obtain an emission between 85 nm and 130 nm (UV light) as shown by George.

Claim 24 is rejected under 35 U.S.C. 103(a) as being unpatentable over Sato in view of Rangarajan, et al. (US Patent 6,451,512).

While clearly showing conversion of at least the top portions of regions of an organosilicon photoresist, Sato does not specify that these top portions be limited to 5% to 75% conversion of the developed organosilicon photoresist to a hardened layer before etching using the hardened layer.

Rangarajan teaches post-developing photoresist silylation in UV to enhance incorporation of silicon (Si) and cross-linking of the resulting organosilicon polymer in the photoresist for increased etching resistance (selectivity) at column 3, lines 14-26, column 4, line 66 to column 5, line 4, column 5, lines 14-42, 58-62, and column 7, lines 51-55. Column 6, lines 58-61 shows use of an inert gas (e.g., Ne, Ar, He, etc.) during the UV treatment. Si atoms are incorporated into the photoresist during UV hardening to a depth of between 2% and 100% of the photoresist thickness (column 10, lines 47-52).

It would have been obvious to one of ordinary skill in the art at the time the invention was made to carry out the UV hardening of Sato as discussed above in order to harden the top 2% to 100% of the developed organosilicon photoresist layer (encompassing the 5% to 75% hardening of instant claim 24) to improve the etching resistance (selectivity) of the organosilicon photoresist layer as shown by Rangarajan.

Response to Arguments

Applicants' arguments filed 06 June 2003 in Paper No. 5 with respect to pending claims 16-24 have been considered but are either moot or not deemed persuasive in view of the new ground(s) of rejection necessitated by currently amended claims 16-18 and 23-24, as discussed above. While applicants have tried to distinguish their invention over the cited prior art by

arguing on page 9 of Paper No. 5 that the hardened top portion of the instant first photoresist is converted to a nitride based hardened layer, this limitation has not been recited in the instant claims and has therefore not been treated on the merits. Applicants argue on page 10 of Paper No. 5 that the Sato organosilicon underlayer 12 is more highly etchable than the resist layer 13 in reference to column 102, lines 16-22 of Sato. However, this higher etchability of the organosilicon underlayer is limited to the organosilicon regions that remain unexposed by an electron beam. In fact, a further reading of Sato shows that the electron beam exposed top regions 16 of the organosilicon underlayer have been hardened by conversion to an oxide/carbide silicon-like film which is highly resistant to subsequent etching and serves as an etching mask (column 101, lines 45-48 and column 102, lines 11-16 and 23-30). Moreover, it is believed that these hardened regions of the organosilicon underlayer 16 are even more resistant to etching than the developed non-organosilicon resist regions 14, as evidenced by comparison of the reduction in thickness of the non-organosilicon resist mask regions 14 between Figure 1C before etching and Figure 1D after etching as taught by Sato. The other reasons for finding the currently amended claims obvious over the cited prior art of record are explained above.

Conclusion

Applicant's amendment necessitated the new ground(s) of rejection presented in this Office action. Accordingly, **THIS ACTION IS MADE FINAL**. See MPEP § 706.07(a). Applicant is reminded of the extension of time policy as set forth in 37 CFR 1.136(a).

A shortened statutory period for reply to this final action is set to expire THREE MONTHS from the mailing date of this action. In the event a first reply is filed within TWO

MONTHS of the mailing date of this final action and the advisory action is not mailed until after the end of the THREE-MONTH shortened statutory period, then the shortened statutory period will expire on the date the advisory action is mailed, and any extension fee pursuant to 37 CFR 1.136(a) will be calculated from the mailing date of the advisory action. In no event, however, will the statutory period for reply expire later than SIX MONTHS from the date of this final action.

Any inquiry concerning this communication or earlier communications from the examiner should be directed to John Ruggles whose telephone number is 703-305-7035. The examiner can normally be reached on Monday-Thursday and alternate Fridays.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Mark Huff can be reached on 703-308-2464. The fax phone numbers for the organization where this application or proceeding is assigned are 703-872-9310 for regular communications and 703-872-9311 for After Final communications.

Any inquiry of a general nature or relating to the status of this application or proceeding should be directed to the receptionist whose telephone number is 703-308-0661.

John Ruggles
Examiner
Art Unit 1756

MARK F. HUFF
SUPERVISORY PATENT EXAMINER
TECHNOLOGY CENTER 1700